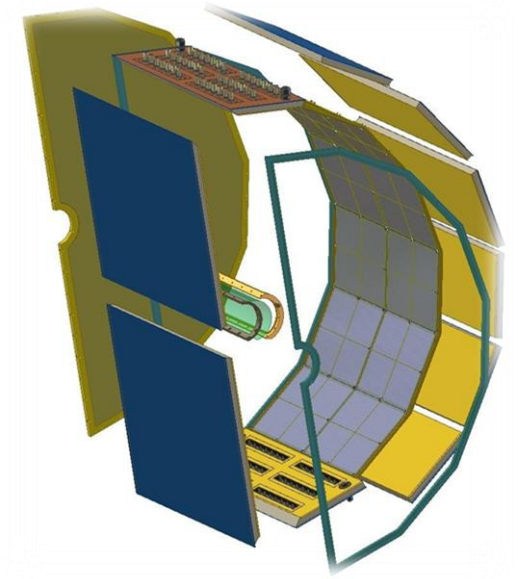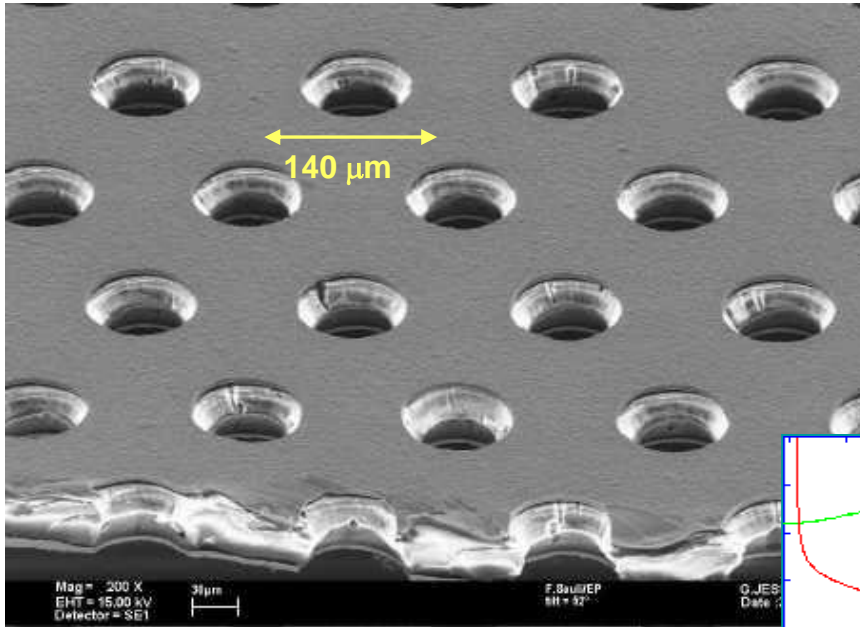# Hadron Blind Detector implementation during PHENIX Run-10

On behalf of the
PHENIX Collaboration

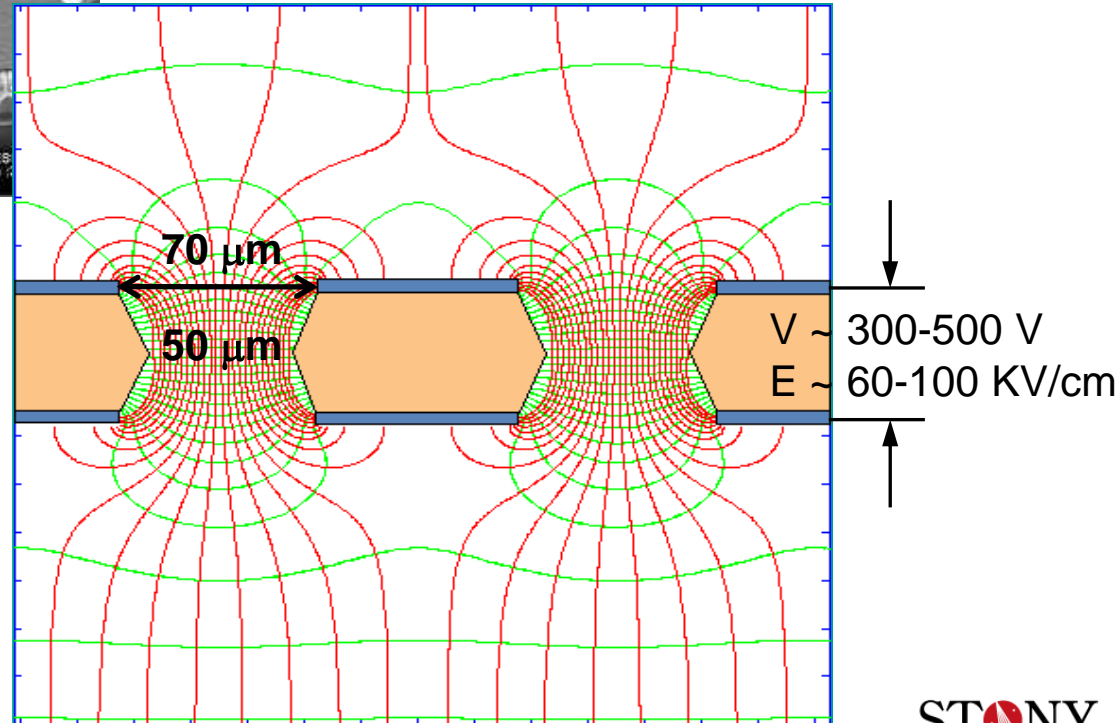# Gas Electron Multiplier

140 μm

- Invented by F. Sauli at CERN (NIM A386 (1997) 531-534)

- Insulating film (Kapton) sandwiched between layers of metal (Cu, Au)

- HV creates strong field so that an avalanche can occur inside the holes

70 μm

50 μm

V ~ 300-500 V
E ~ 60-100 KV/cm

Gas Gains ~ 10-20 / GEM foil

~ 10^3-10^4 or higher in triple-GEM configuration
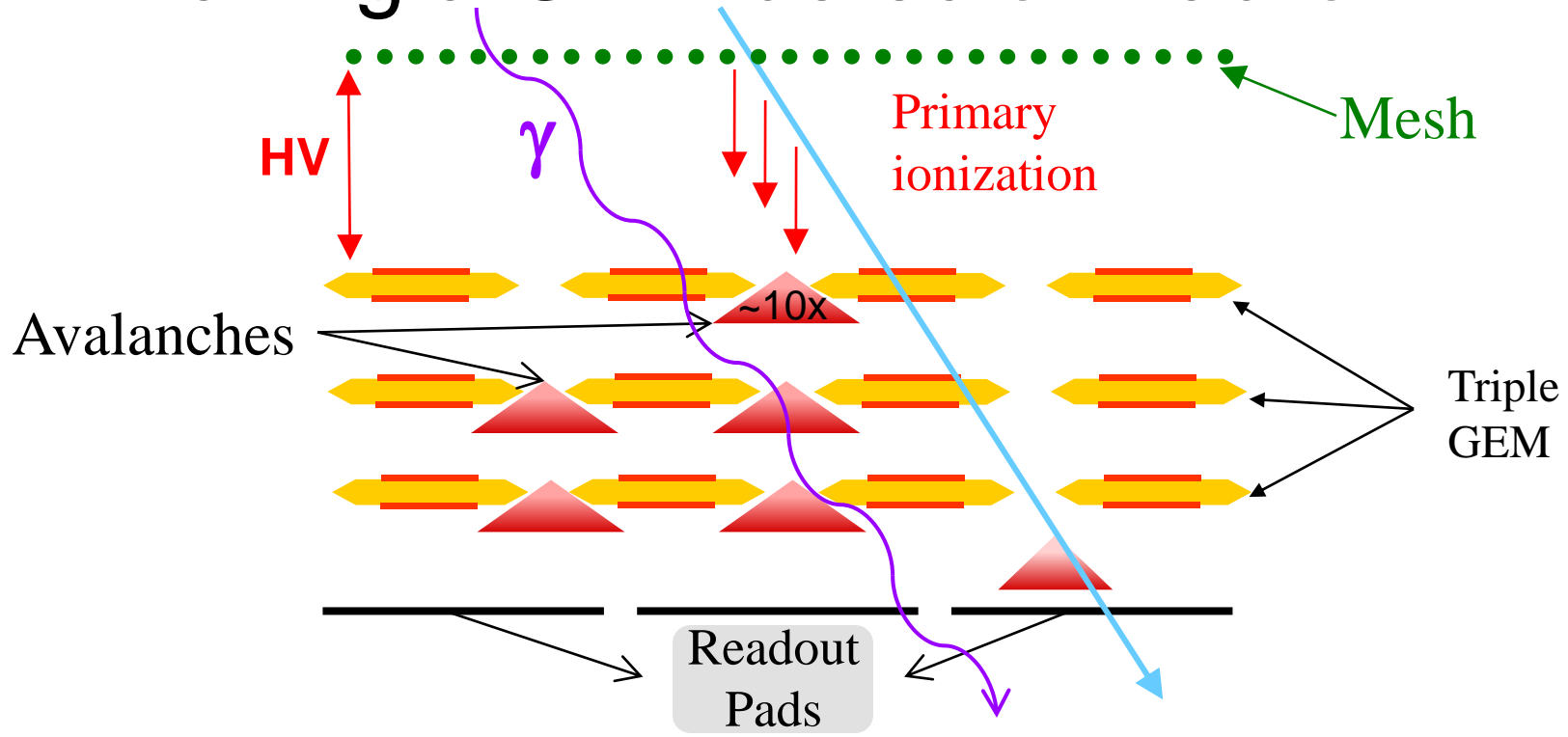
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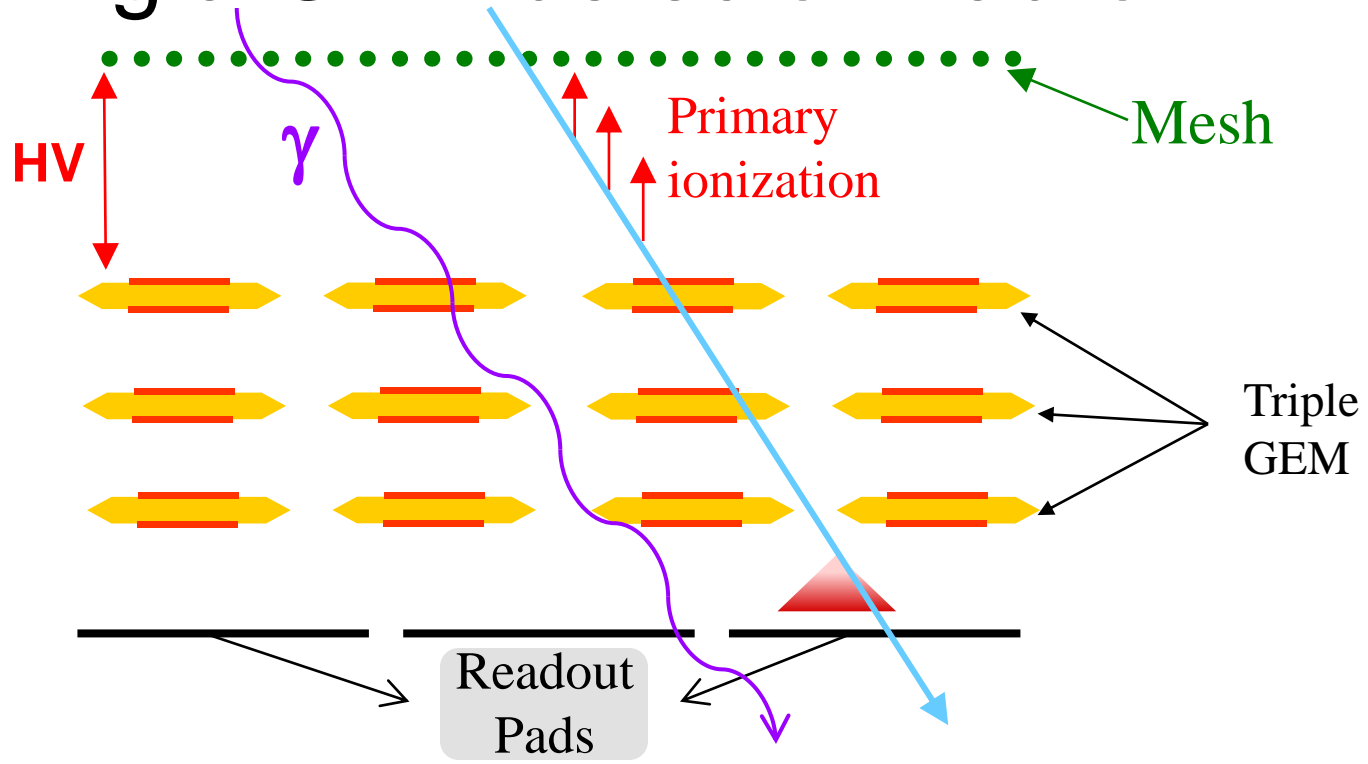STATE UNIVERSITY OF NEW YORK

Making a GEM detector Hadron Blind
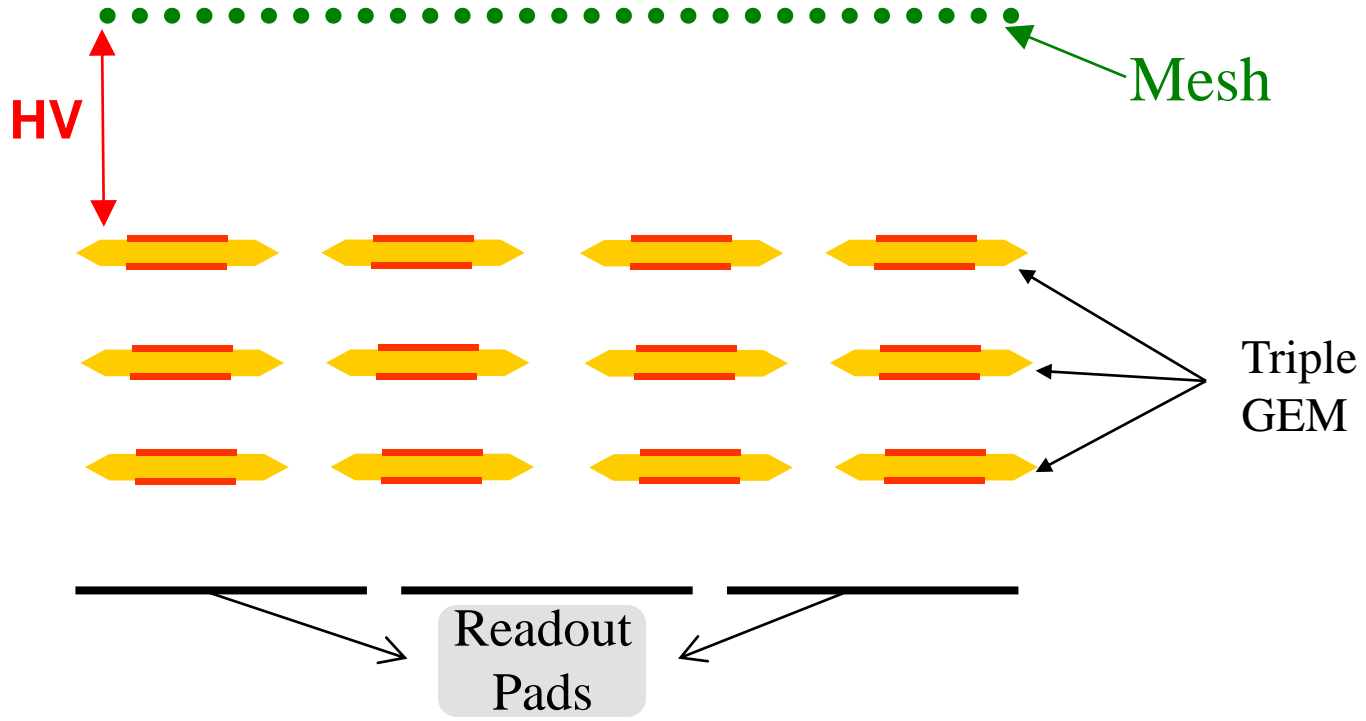
- Triple GEM stack with wire mesh and Readout Pads

Making a GEM detector Hadron Blind

- Triple GEM stack with wire mesh and Readout Pads

- Ionization from charged particles avalanche and charge is collected on Pads

Making a GEM detector Hadron Blind

- Apply reverse-bias voltage on mesh-GEM → primary ionization drift away from GEM

Making a GEM detector Hadron Blind

HV

γ   e⁻   Primary ionization

Mesh

CsI layer

~10x

Avalanches

Triple GEM

Readout Pads
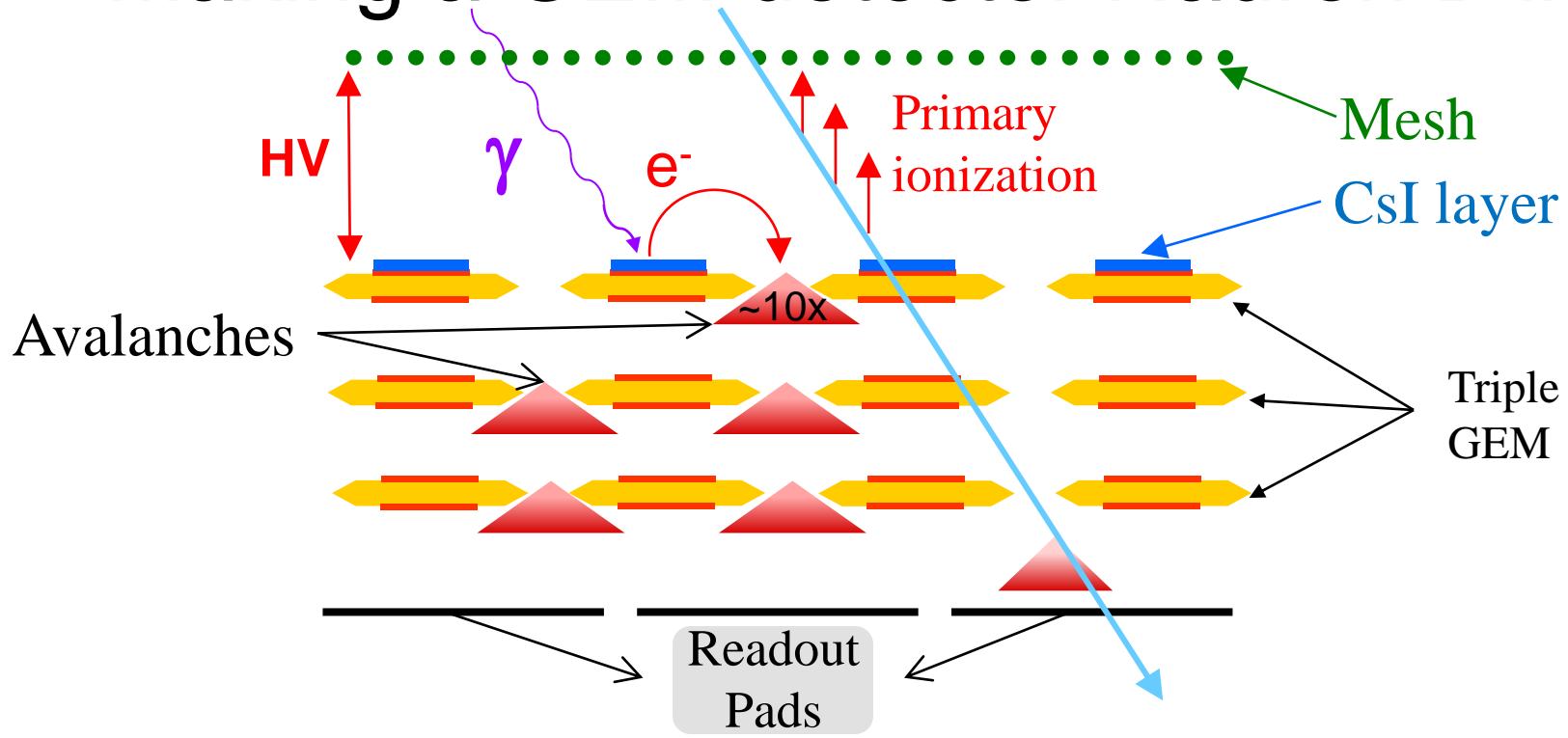
- Apply reverse-bias voltage on mesh-GEM → primary ionization drift away from GEM

- Deposit photocathode (CsI) on top GEM → UV photons produce photoelectrons from the CsI photocathode

  – Photoelectrons avalanche in the holes, charge collected by Readout Pads.

  – Triple GEM stack yields a gain of a few x 10^3

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The Degree of Hadron Blindness
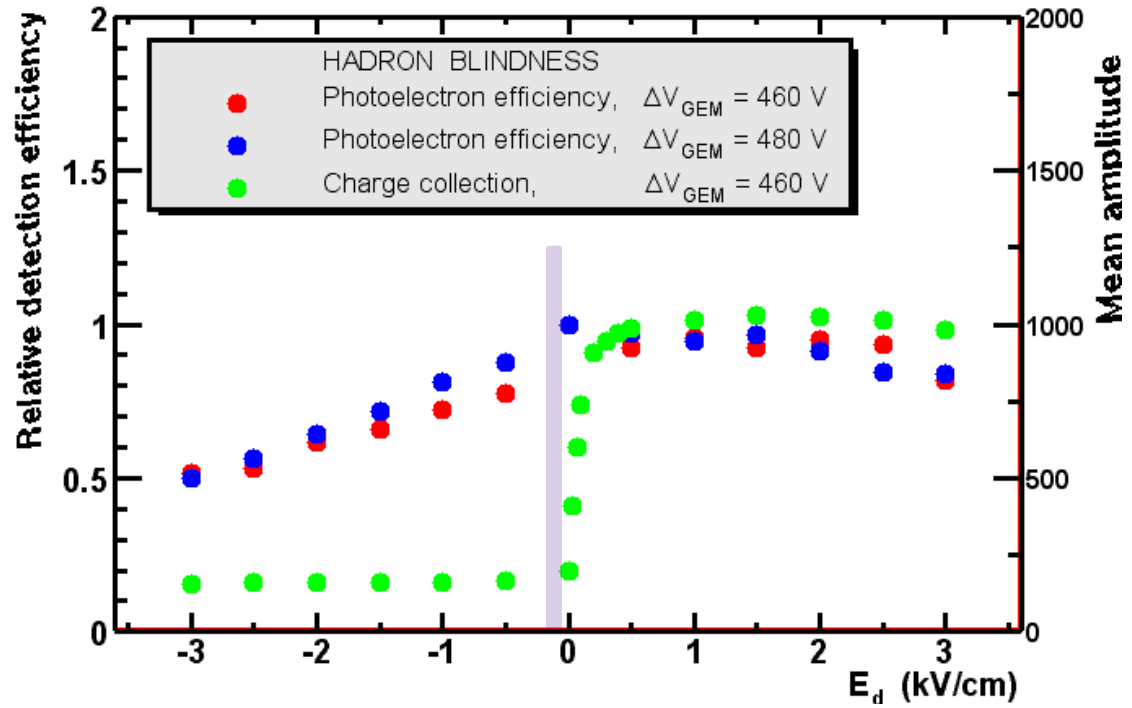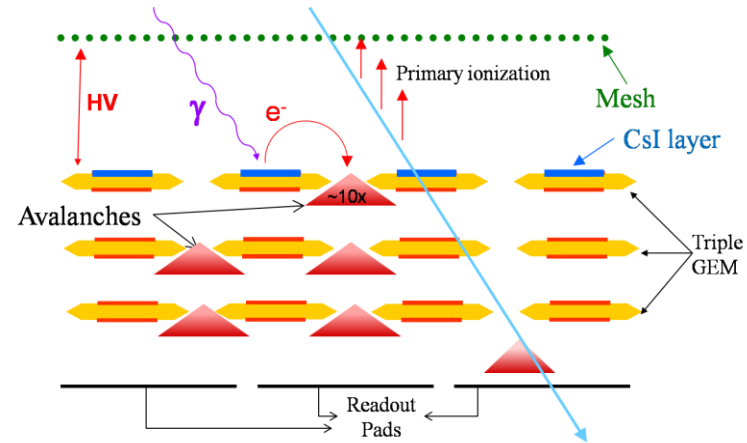
- At slightly negative E_d, photoelectron detection efficiency is preserved while charge collection is largely suppressed.

Proximity Focused Windowless Cherenkov Detector (HBD)

HBD Gas Volume: Filled with CF_4 (L_{RAD}=50 cm)

Radiator gas = Avalanche Gas

Cherenkov light forms "blobs" on an image plane (r_{BLOB}~1.8cm)

Θ **= Pair Opening Angle**

e$^+$

e$^-$

Θ

55 cm

5 cm

PCB pad readout (~ 2x2 cm^2)

CsI photocathode covering GEMs

Electrons radiate, but hadrons with P < 4 GeV/c do not

Triple GEM detectors (10 panels per side)

Dilepton pair

Black Kapton window around beampipe

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HBD in PHENIX

PHENIX Detector
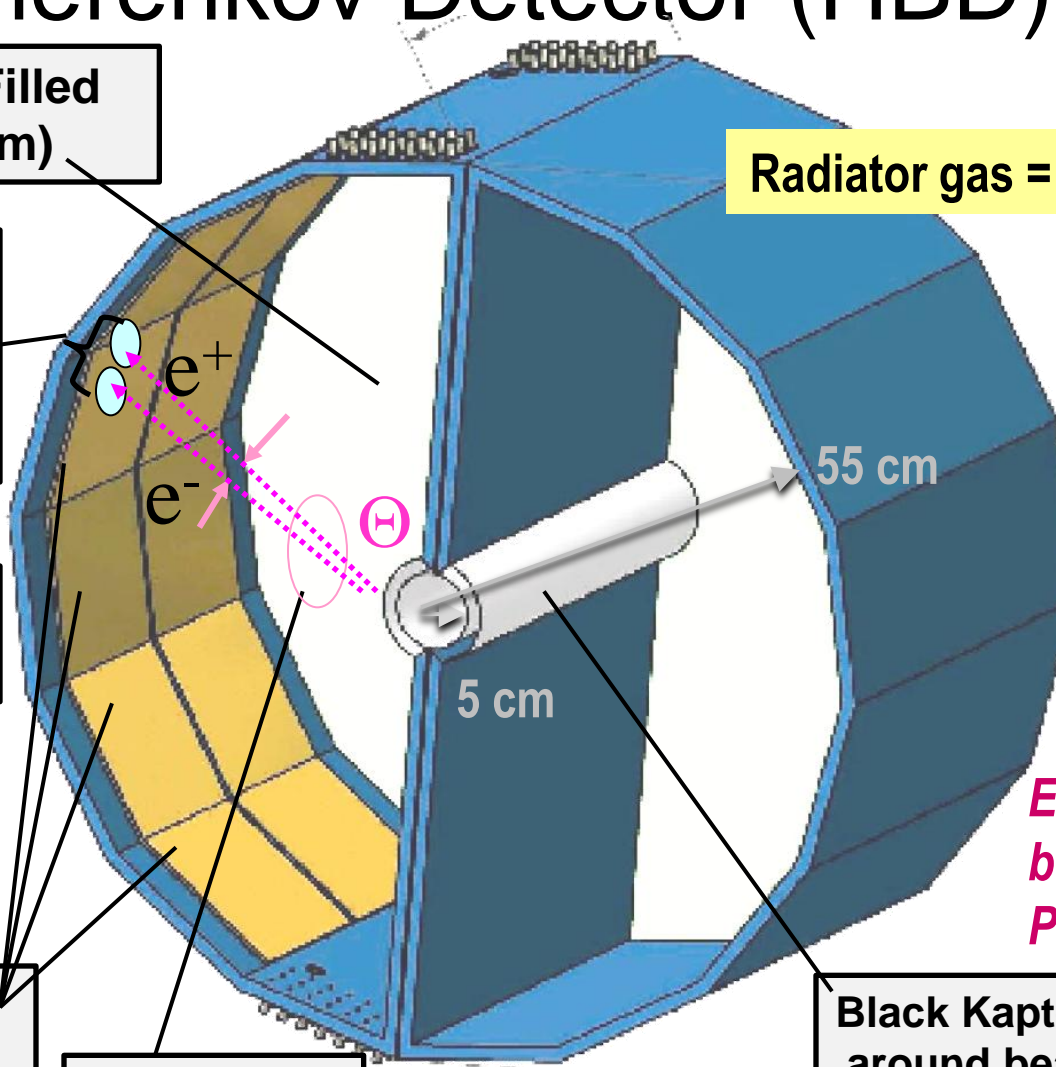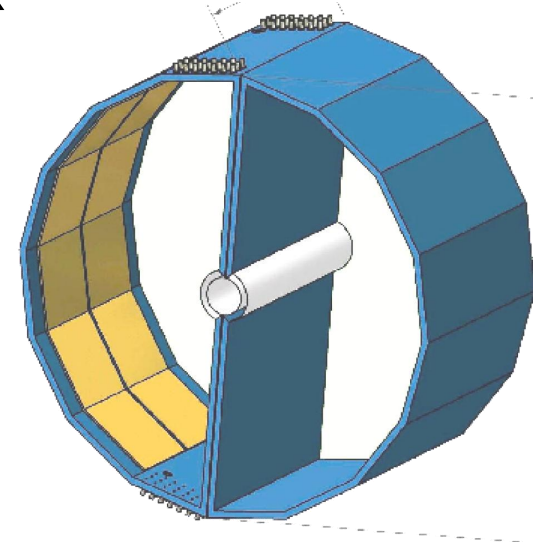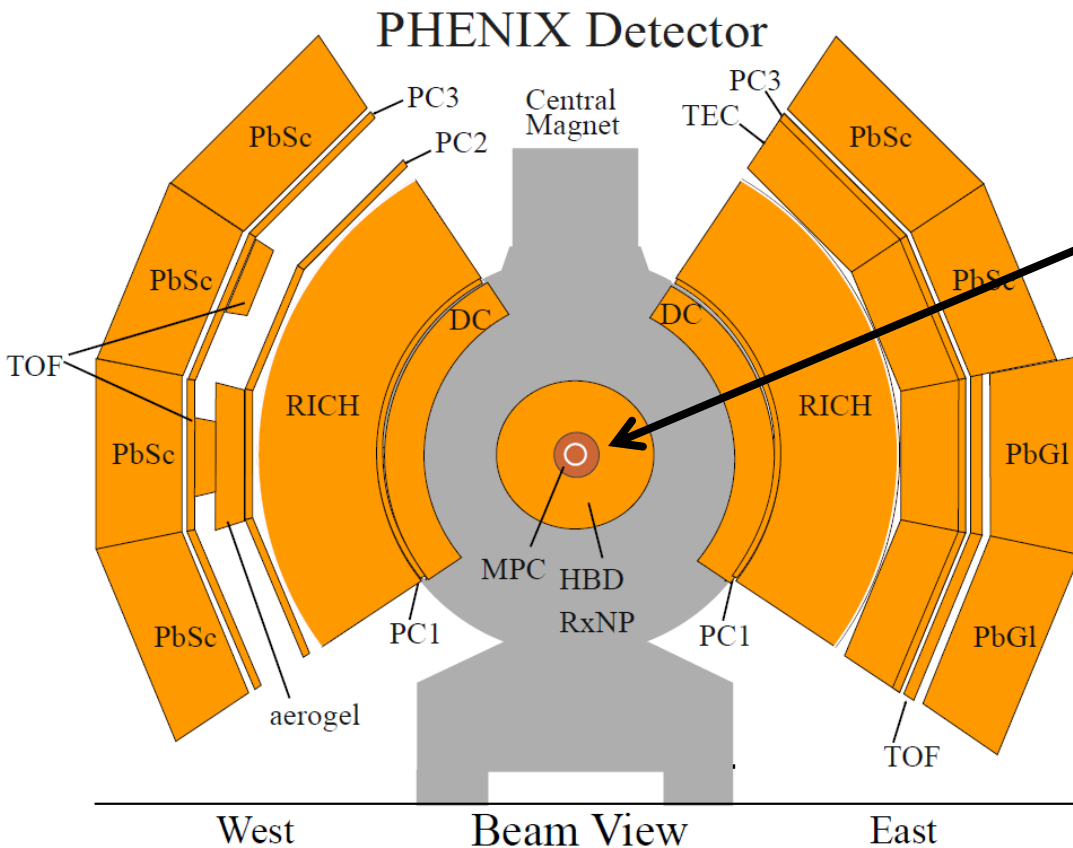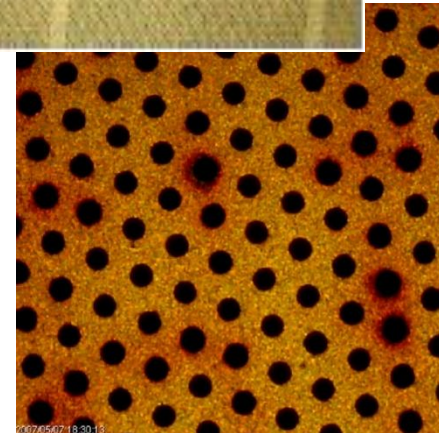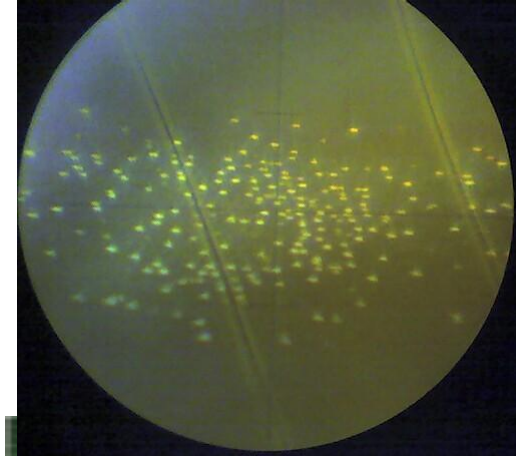

- Backgrounds due to low momentum electrons from Dailtz pairs & conversions can be reduced with HBD detection of electrons
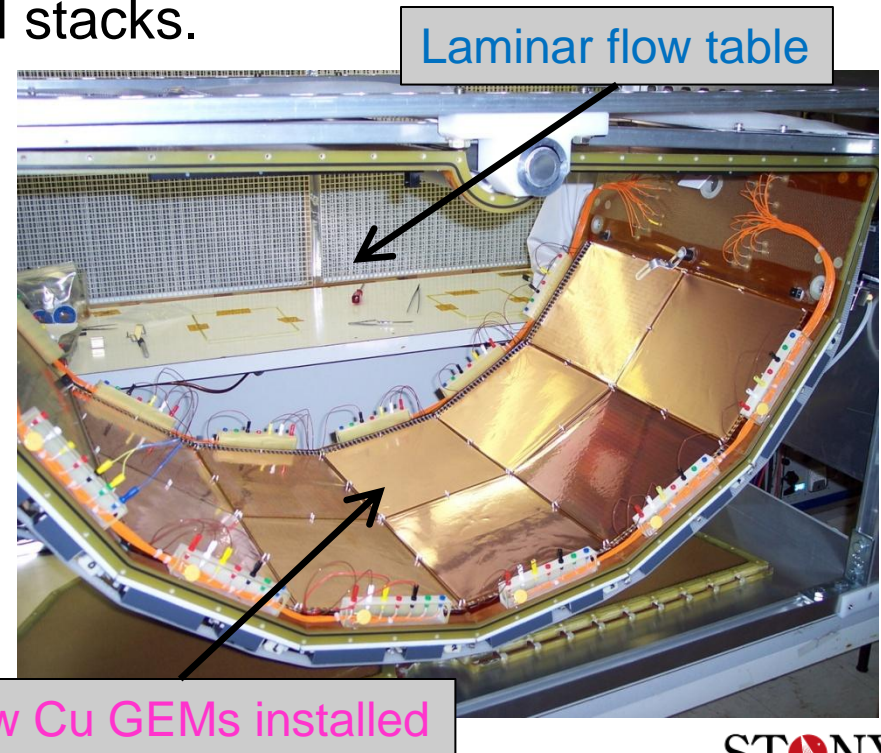
HBD History

- Fall 2006 – installed in PHENIX for Run-7 (2006-07).
  - HBD's GEM foils were damaged due to severe HV problems
    - Minor GEM sparks induced damaging mesh to GEM sparks.
    - A spark would induce more sparks in other modules due to a copious production of photons from original spark.

- Rebuilt & installed for Run-9 (Feb. – July' 09)
  - Built HBD-East using time consuming "test, test, and install method".
  - Built HBD-West using M. Durham's Rapid Assembly Method.

HBD History …

- HBD-East Problems during Run-9:
  - Mesh-GEM short in 1 module (early in run)
    - Disabled module ES1.
  - Another module had deteriorating performance.
  - Sparking resulting in trips cause subpar data collection.
- HBD-West had no major problems during Run-9
- Decision to rebuild HBD-East
  - Known difference in assembly method of East/West arms.
  - Deterioration in performance continuing into Run-10 a possibility.
  - Time scale to rebuild was sufficient.

Rebuilding of HBD-East

- M. Durham's Rapid Assembly Method.
  - Individual GEMs: clean, condition w/HV, test.
  - Assemble bottom & middle GEMs in an easy to access, clean environment (adjacent to laminar flow table).
  - Install top GEMs (CsI coated) in Nitrogen filled glove box.
  - Seal HBD vessel, then test GEM stacks.

Laminar flow table

New CsI coated GEMs installed

Glove Box

New Cu GEMs installed

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Problem with HBD module EN2

- Testing of HBD-East showed that GEM stack EN2 could not hold the nominal operating voltage
  - Each individual GEM able to maintain a voltage exceeding nominal operating voltage.
  - Possibly due to small dent in a GEM.
  - Workaround solution adopted.
    - Revert voltage divider to older design, which maintains a lower voltage
    - Eventually shorts developed leading to trips… EN2 was disabled.
- Other attempts at fixing EN2 have failed
  - Currently EN2 is disabled
  - 5% acceptance loss

Creating Au+Au Events from p+p events

- HBD is very efficient at determining tracks from p+p events.
- Instead of using Monte Carlo, use real data by accumulating many p+p events to emulate one Au+Au event.
  - p+p tracks for each individual events are well determined.
  - HBD reconstruction will be less efficient in determining Au+Au tracks due to overlapping of tracks.
  - Obtain electron identification in Au+Au collisions by comparing "Accumulated" Au+Au events to known p+p reconstructions.
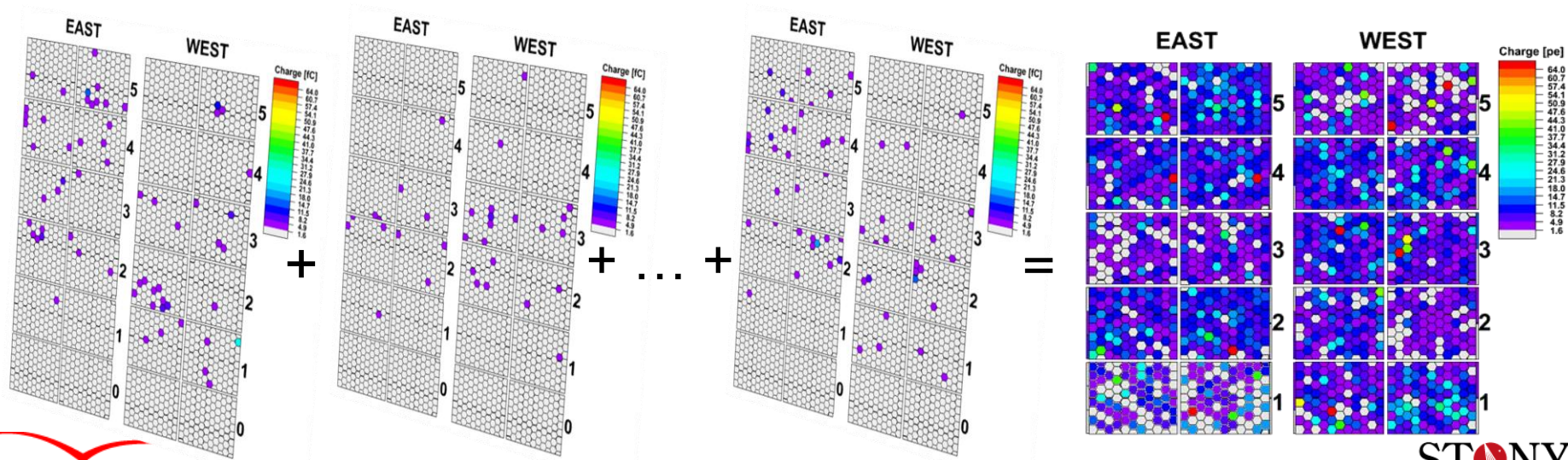
Conclusions

- Rapid Assembly Method proved successful.
- HBD-East rebuild improved performance
  - Module EN2 disabled, 5% loss of acceptance .
  - Remaining HBD-East modules working as expected.
- p+p event accumulator will allow determination of the HBD's electron identification efficiency.
- Due to the HBD, PHENIX has the added benefit of suppressing Dalitz pairs and photon conversions.
- For more on HBD, stick around for Sky Rolnick's *Chiral Symmetry Restoration using HBD* following this talk.

Extras

HBD Detector Parameters

Acceptance $|\eta| \leq 0.45$, $\Delta\phi = 135^o$

GEM size (ϕ, z) 23×27 cm^2

Segmentation   26 strips (0.80×27 cm)
                                                      2 strips (0.65×27 cm)

Number of detector modules per arm   10

Frame   5 mm wide, 0.3mm cross

Hexagonal pad size $a = 15.6$ mm

Number of pads per arm   960

Dead area within central arm acceptance   6%

Radiation length within central arm acceptance   box: 0.92%, gas: 0.54%,
                                                    preamps+sockets: 0.66%
                                                    Total: 2.12%

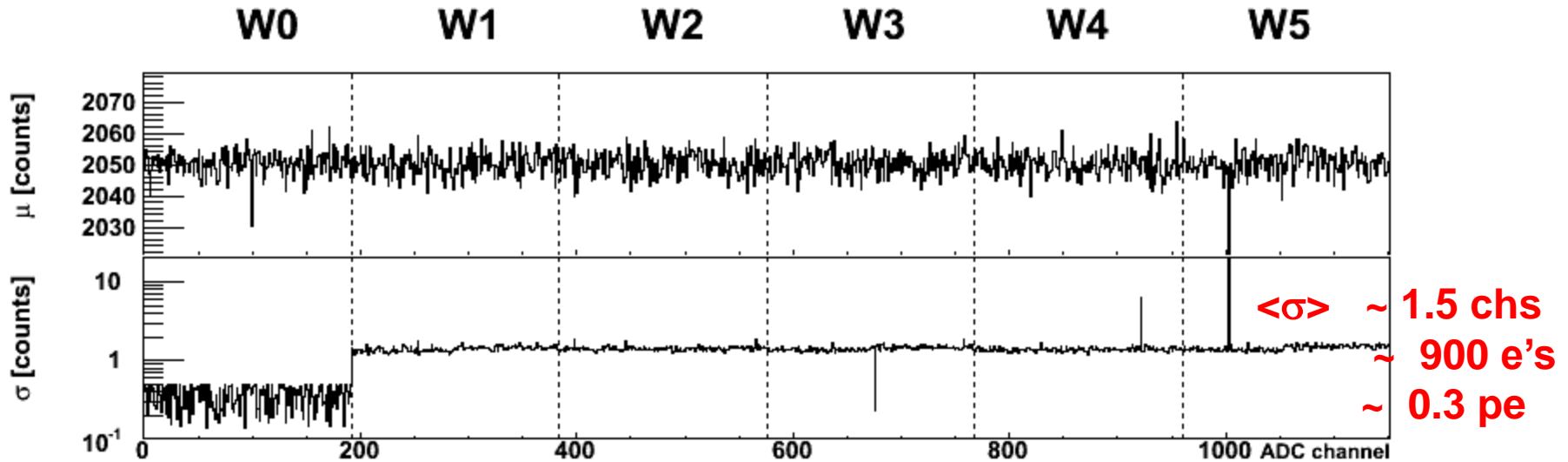Weight per arm (including accessories)   <10 kg

HBD Assembly Area (Clean Tent)

Laminar flow table

Evaporator

Glove Box

GEM vacuum storage vessel
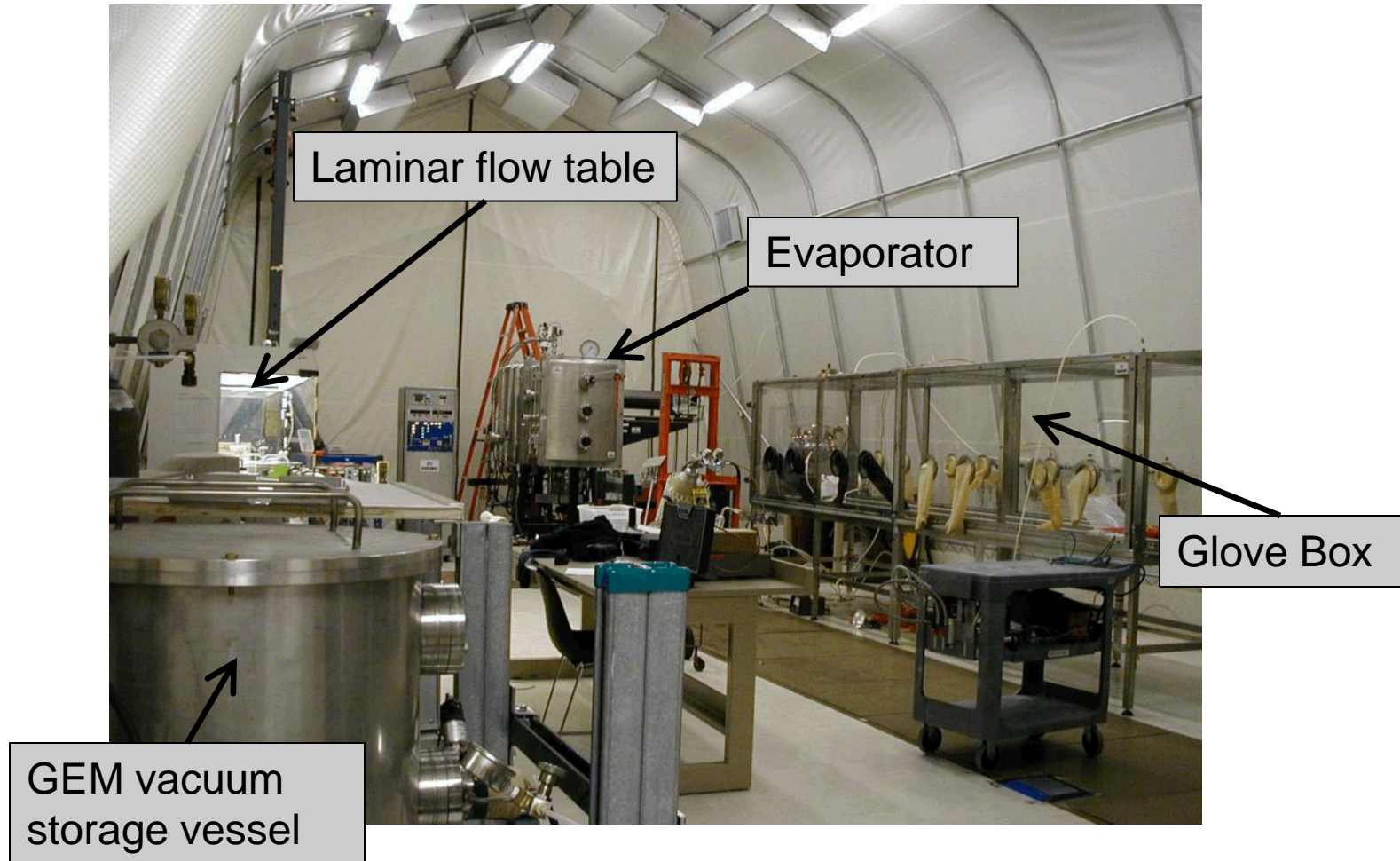
Reduced Data Format for Run-10
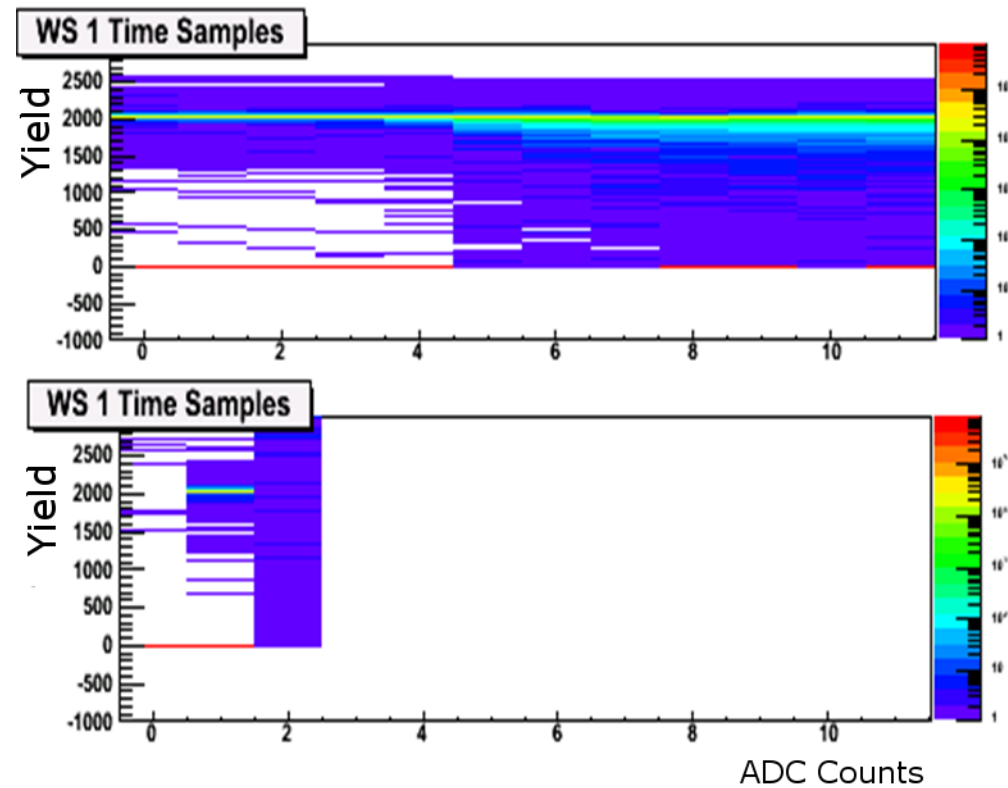
Old 12 sample format
Data volume ~ 20-24 KB/ev
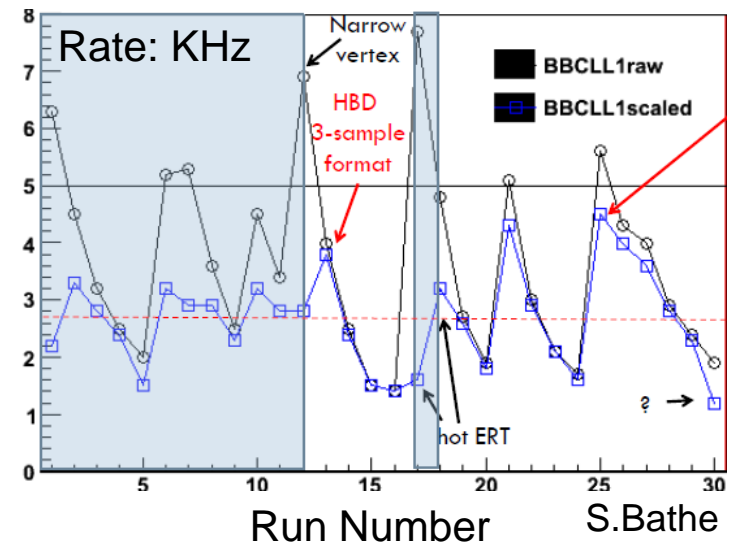
New 3 sample format
Data volume ~ 7-8 KB/ev

Pedestals and Noise

$\langle\sigma\rangle$ ~ 1.5 chs
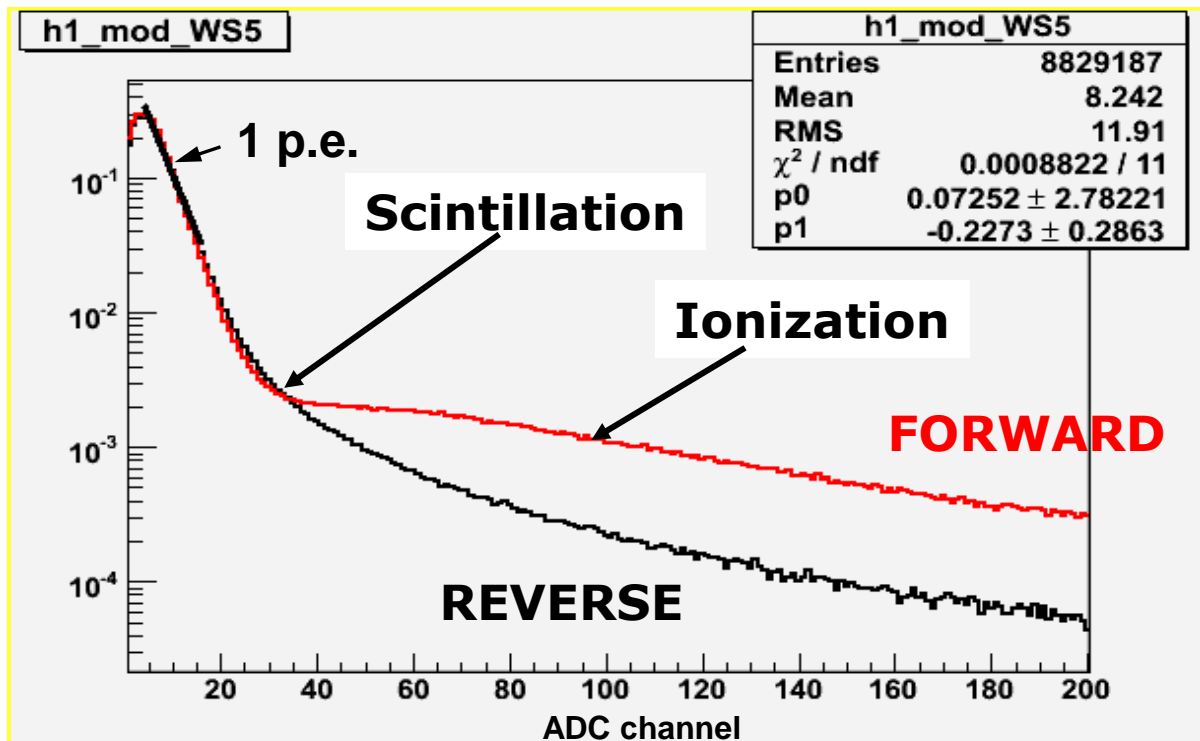   ~ 900 e's
      ~ 0.3 pe

New format
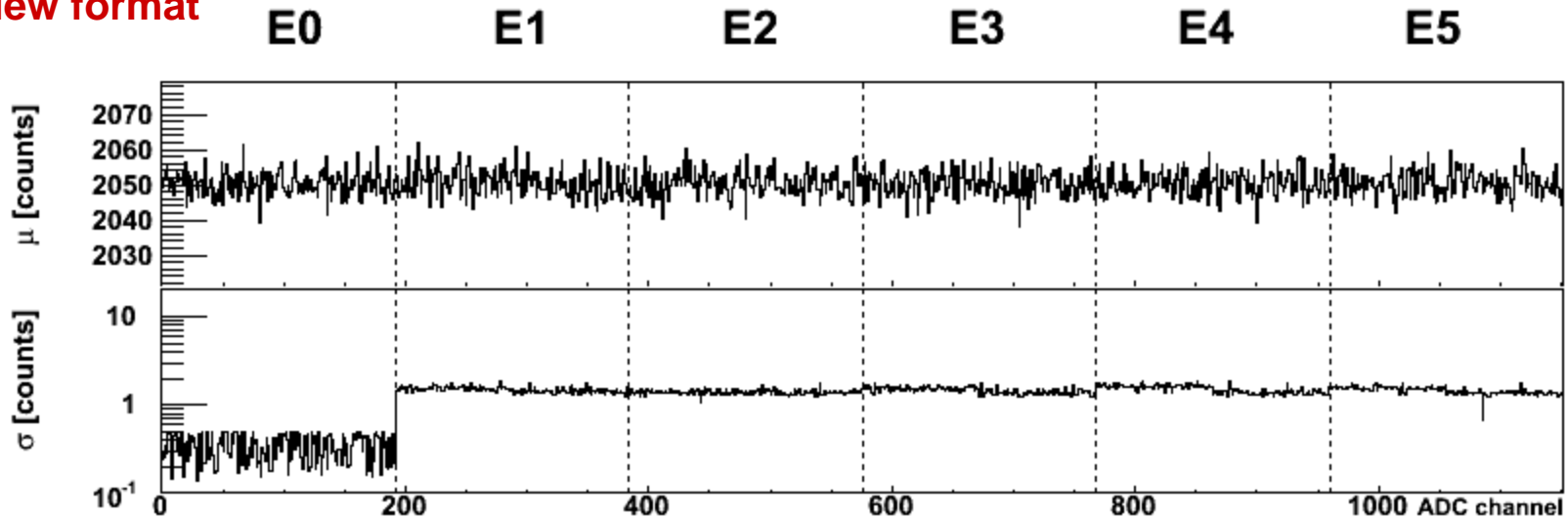
Gain Determination Using Scintillation in CF_4

For low multiplicity events, scintillation produces essentially single photoelectrons on each pad

Fit single p.e. distribution to an exponential

Gain ~ 1/slope

Allows pad by pad calibration

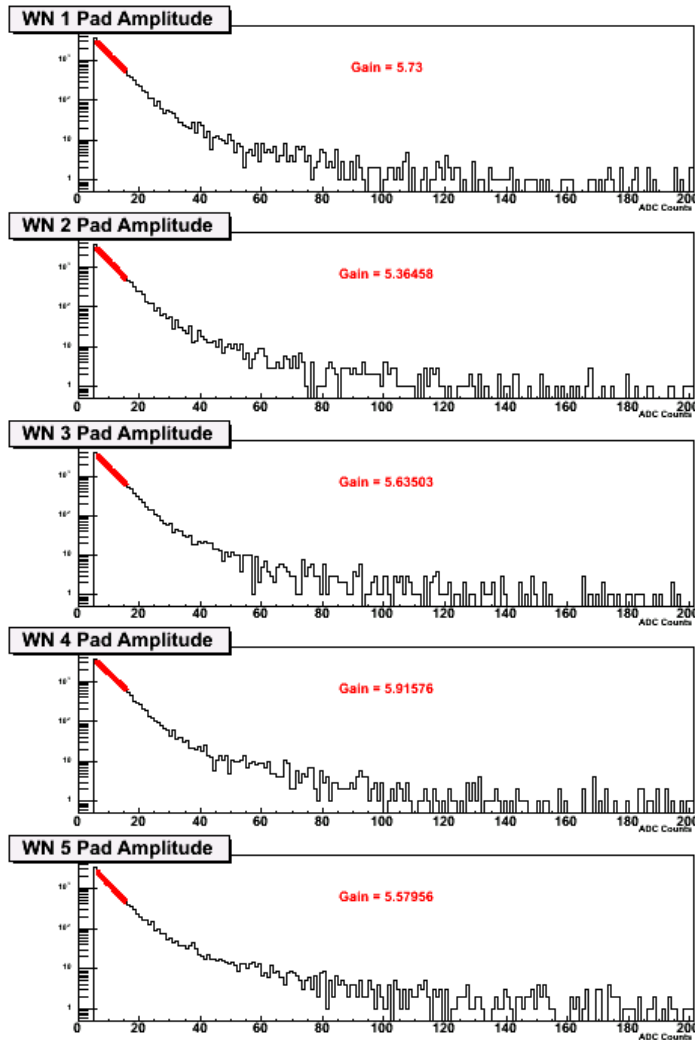Used as a gain monitor throughout the run
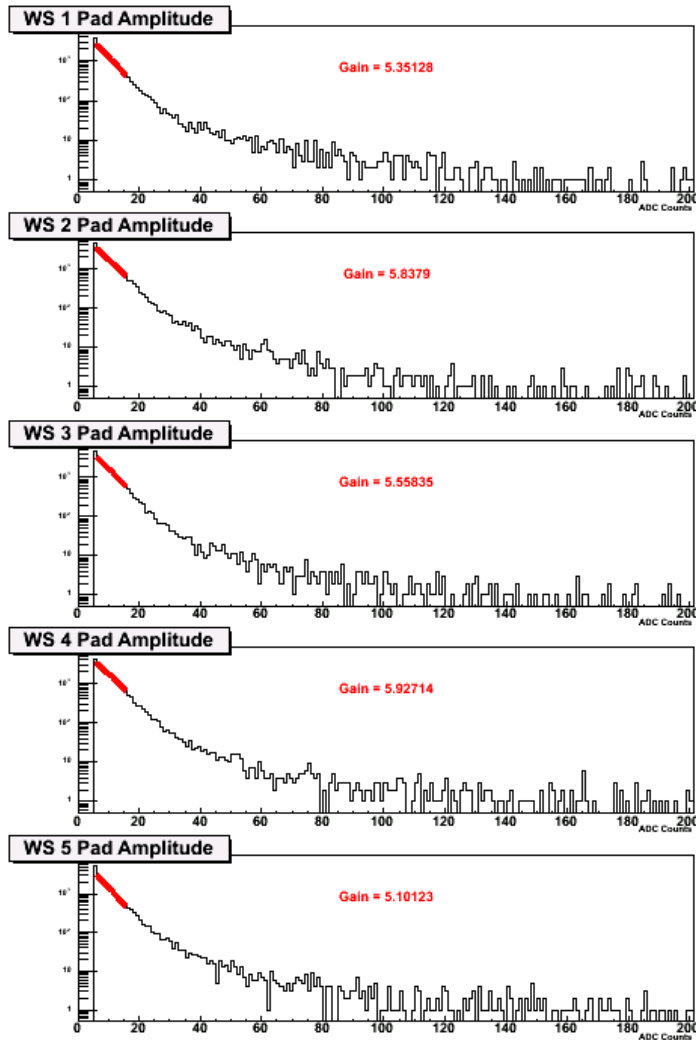
Setting Gains Using Scintillation
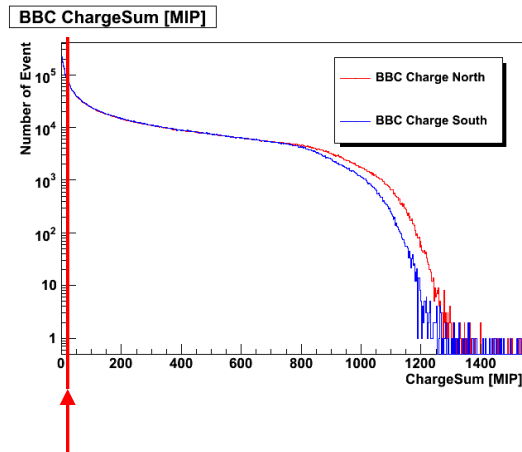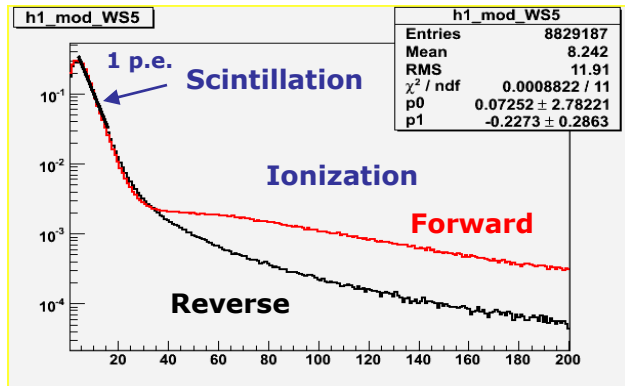
Select on most peripheral events where <Npe> << 1
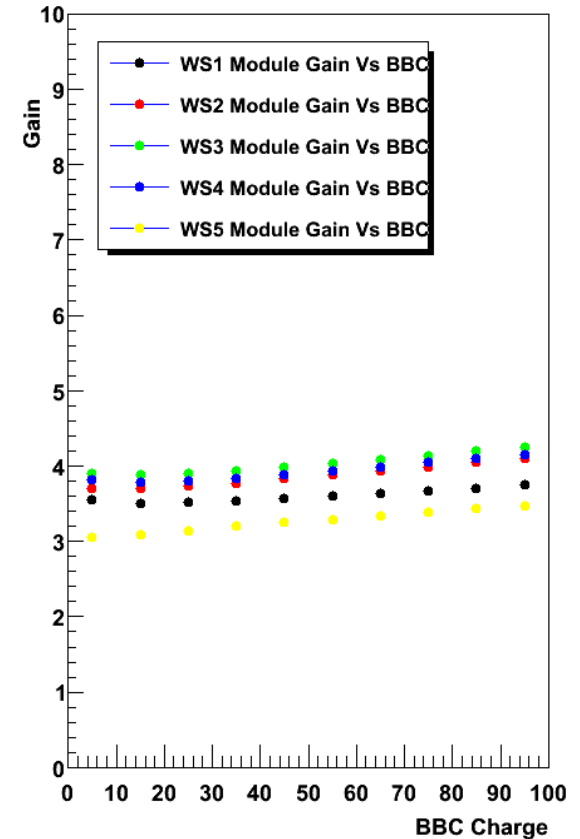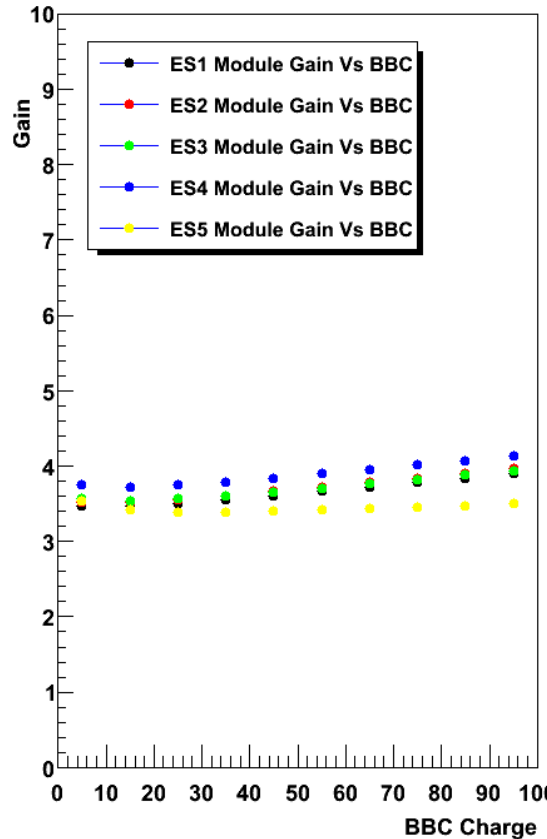
S.Rolnick

West Gains

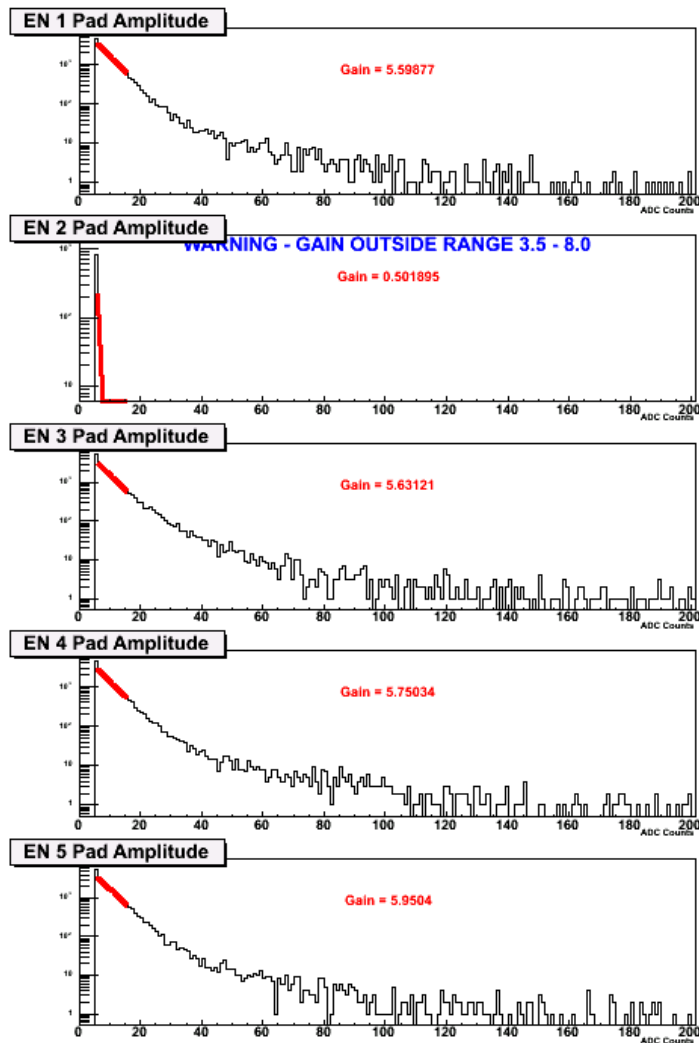# East Gains
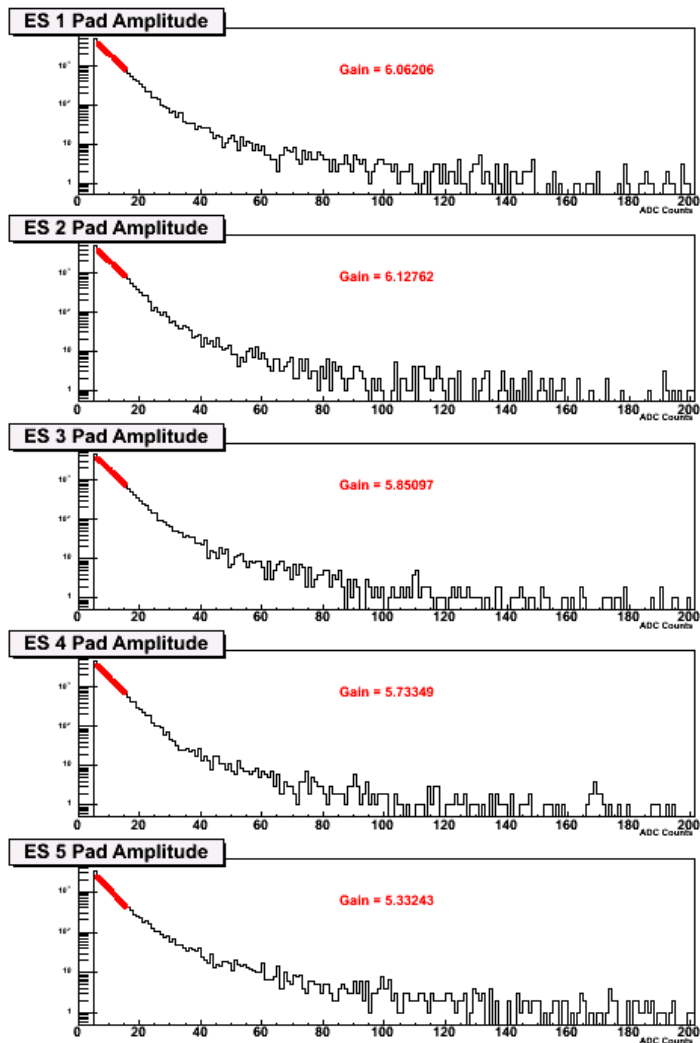
Setting Reverse Bias Voltages
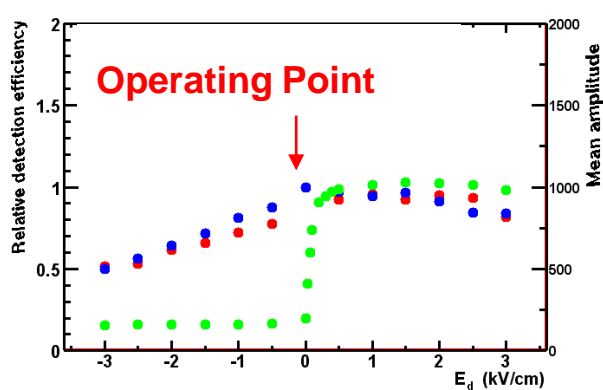
Need to set reverse bias voltage to optimize pe collection efficiency and minimize hadron response

Requires setting voltage between mesh and top GEM to ~ 5V

Applied voltage is ~ 4KV, so this requires high precision (~ 0.1%) and good stability in the HV PS